Digitalization of Requirement Analysis in Nursing Robotics
Digitalisierung der Anforderungsanalyse in der Pflegerobotik

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Introduction

Musculoskeletal disorders (MSD) are widespread among nursing staff. MSD are one of the central contributors for nurses to leave their job, which then further increases the workload on the remaining nurses [1]. Despite efforts from industry and academia to find (technical) solutions to relieve nurses from heavy physical work, an efficient and accepted solution for avoiding MSD has not been found so far. One reason for this may be a disconnect between perceived and actual needs of the nursing staff leading to the development of solutions that do not tackle the origin of MSD. To get to the root of MSD issues in nursing professionals, we believe that analyzing first the activities of nurses would allow us to obtain a better understanding of activities that might lead to the development of MSD. In particular, we believe that physically exhausting activities, which involve movements in either highly unergonomical positions, movements that require heavy lifting, or both at the same time can contribute to MSD. Identifying the respective physically burdening activities of nursing professionals in general and for the individual nurse in particular should allow us to better address the real needs. Accordingly, dedicated technical solutions can be developed that bring physical relief either for specific body regions that are repeatedly involved in non-ergonomic movements or for specific tasks that are particularly demanding [2]. So far, the most common methods used for activity recognition were based on different types of classifiers. Although simpler movements like walking, running, standing, and sitting can be recognized by just using Inertial Measurement Units (IMUs) with high accuracy ($> 95\%$) [3], more complex movements like daily activities are commonly analyzed using cameras to allow reliable recognition [4]. Since the use of cameras may be difficult in a nursing environment due to sensitive patient data [5], a reliable approach without the use of visual recording devices is needed. Therefore, in this work, we will test the feasibility of using IMU data and preparing it for application in Convolutional Neural Networks (CNNs) [7] for classifying different tasks that are common in the field of nursing. In total, 4 healthy participants performed 7 different tasks with a setup using 10 IMUs.

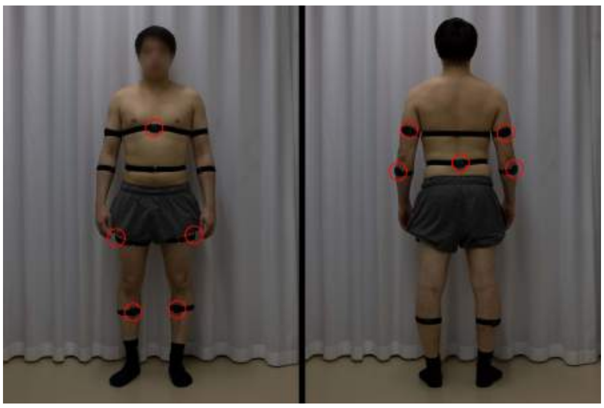

Figure 1 Sensor setup of a participant. All sensors are attached by elastic straps.

Figure 2 Participant at the start of a bed to wheelchair transfer of a mannequin.

Materials and Methods

All measurements were done at Balgrist Campus Zürich, using 10 ZürichMOVE IMUs. The IMUs were mounted at the arms, legs and torso and measured at 200Hz (see Figure 1). Four nursing tasks and three everyday movements were recorded with four subjects. The nursing tasks covered: i) bed to wheelchair transfer, ii) wheelchair to bed transfer, iii) leg rearrangement of the patient, and iv) mobilization (horizontal displacement) on the bed (see Figure 2). The three everyday movements were v) sitting, vi) standing, and vii) walking. Each movement was recorded separately (120 repetitions of each task for participant 1 and 100 repetitions for the other participants). Data was first pre-processed, i.e. all 10 sensors were synchronized, all movement repetitions were isolated, data was down sampled from 200Hz to 50Hz, and segmented into 10s windows with 20% overlap. This resulted in 4 data sets, which were converted into RBG images [7]. The data sets were then fed into a shortened version of the InceptionV3 CNN, which is available on Matlab. The performance of the CNN was determined by using leave-one-subject-out cross-validation [8].

Results

The mean performance of the 4-fold cross validation is summarized by a confusion matrix (see Figure 3).

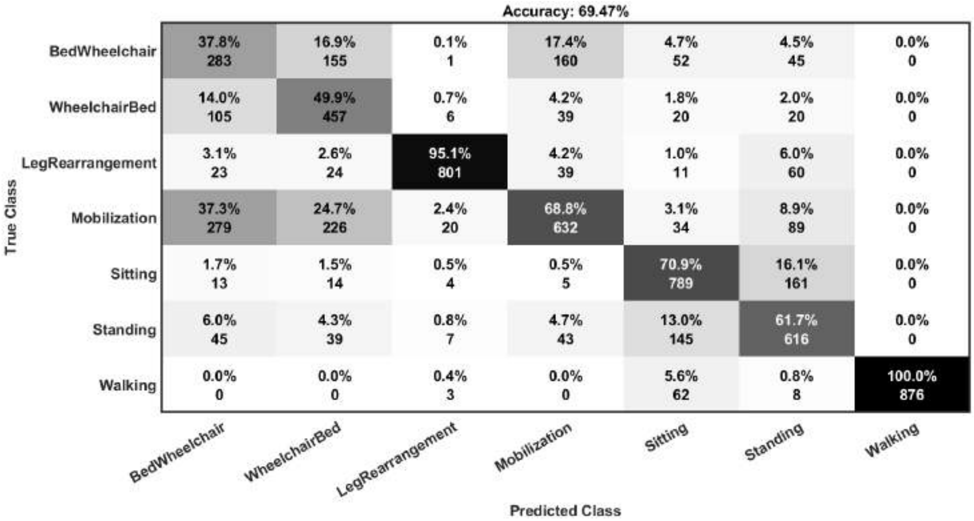

Figure 3 Performance of CNN with 50Hz data input, forearm sensors included

Discussion and Conclusions

This work shows a simple sensor setup and data analysis approach to recognizing nursing tasks without visual data. The CNN trained by relatively sparse data shows already reasonable performance (mean accuracy 69.2%) for 7 classes and has the potential to be applicable in a real-world environment due to its low profile and simple mounting or integration into nurses' clothing. For future applications, a refinement of tasks and model parameters (window size, overlap, and CNN structure) will be performed. Also inclusion of more participants will be necessary to further proof general applicability of our approach for the nursing environment.

Literatur

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